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BULLETIN

OF THE

TORREY BOTANICAL CLUB

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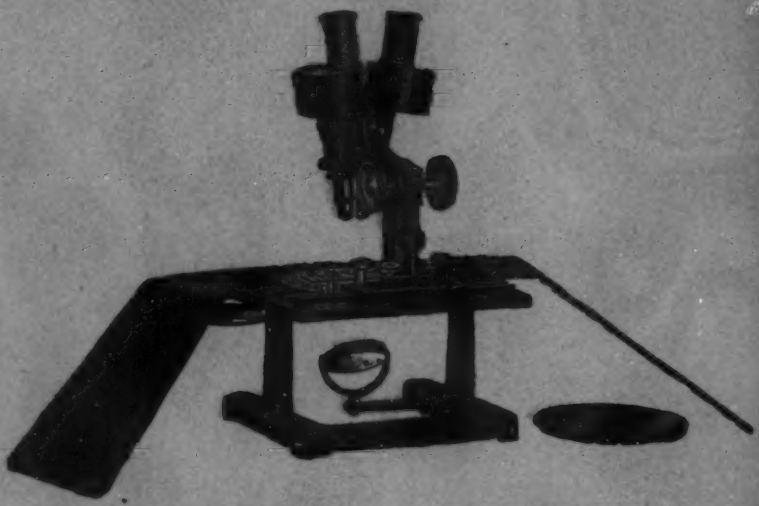

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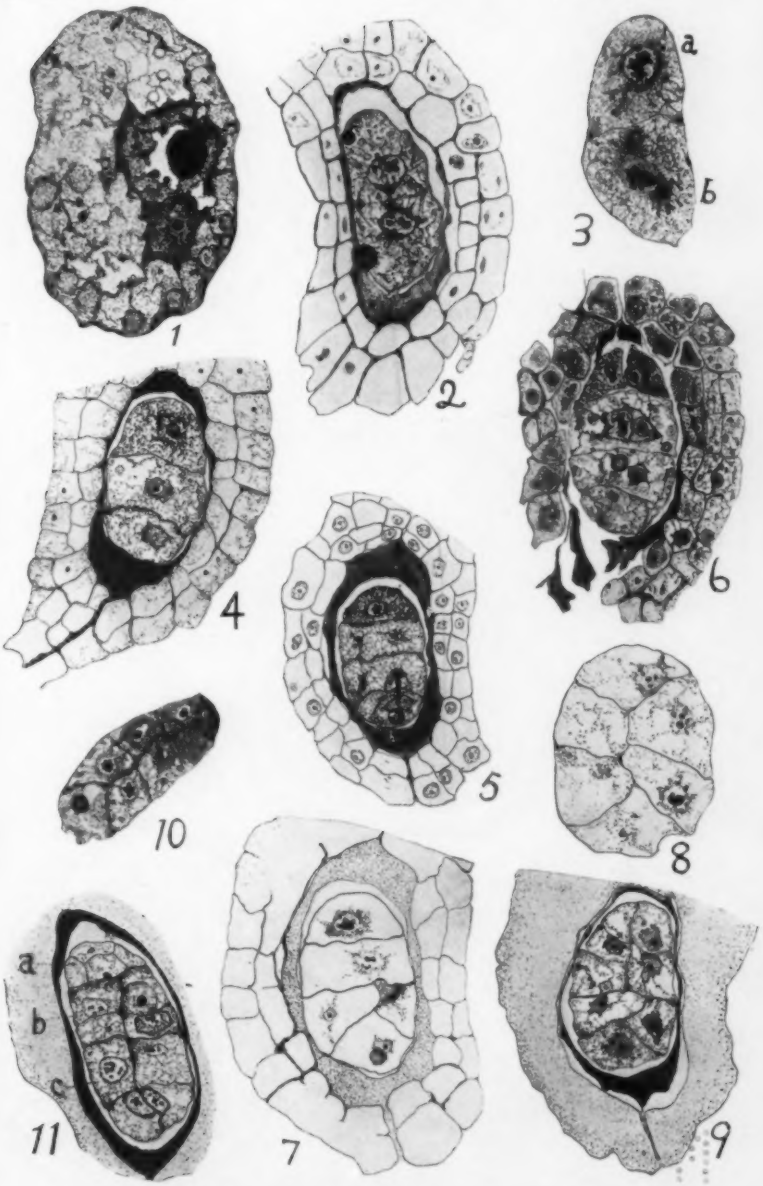

WOODBURN: EMBRYOLOGY OF REBOULIA

Vol. 46 No. 12

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DECEMBER, 1919

Preliminary notes on the embryology of Reboulia hemisphaerica

WILLIAM L. WOODBURN

(WITH PLATE 19)

The object of this paper is to present a part of a more extended study on the embryology and cytology of *Reboulia hemisphaerica* (L.) Raddi. Only certain stages in the process of fertilization and in the early development of the embryo sporophyte will be considered at this time. The description of various other stages in the life history together with a summary of the previous literature on *Reboulia* will be left for a subsequent report.

FERTILIZATION

The male gamete in the bryophytes may undergo two series of marked morphological changes. The first series includes the steps leading from the non-motile condition of the androcyte (the cell which directly becomes transformed into the mature sperm) through the formation of the actively motile free-swimming sperm. The second series includes the reverse steps and occurs in those cases where a sperm reaches an egg. In this second case the motile sperm becomes again non-motile with a resting nucleus similar to that of the androcyte or androcyte mother-cell. Details of the main stages in the first series have been carefully described for numerous liverworts and mosses. The processes accomplished in the second series, after the sperm reaches the egg, are not so well known. However, soon after

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reaching the egg the sperm nucleus is found to have the form and structure of a nucleus in the resting stage (FIG. 1). Quite similar conditions have been reported by Black (1) and Garber (3) for *Riccia* and by K. Meyer (4) for *Corsinia*. The form and structure of the egg and sperm nuclei at this stage are to a certain extent similar (FIG. 1). The egg nucleus is larger and shows a coarser and more open disposition of the chromatin. An unstained area surrounds the nucleolus. A smaller nucleolus is present in the sperm nucleus. The latter as a whole stains somewhat more heavily than does the nucleus of the egg.

The accompanying figures are drawn as nearly as possible in that position which is occupied in nature. For instance, the necks of the archegonia at this stage of development project obliquely downward or toward the substratum. Consequently it will be seen that, in FIG. 1, the sperm nucleus lies in contact with that side of the egg nucleus which is toward the neck of the archegonium. The membrane of the egg nucleus is somewhat infolded along the surface of contact.

Compared with corresponding stages in the life history of gymnosperms and angiosperms we know very little concerning the details of nuclear behavior in this and further stages of fertilization.

EARLY DIVISIONS OF THE EMBRYO

The first division wall of the zygote is laid down transversely. FIG. 2 represents the telophase of this first division, with the cell plate in the process of formation. The spindle lies parallel with the longitudinal axis of the venter of the archegonium; consequently a transverse basal wall results (FIGS. 2 and 3). In FIG. 3 the nuclei are in the prophase of subsequent division; "a" represents the hypobasal cell or that one next to the base of the archegonium, and b, the epibasal cell or that one next to the neck of the archegonium. The second division is transverse and occurs in the epibasal cell (compare FIGS. 3, 4, 5 and 6). The epibasal cell (FIG. 3, "b"), with the chromosomes clearly differentiated, is in a more advanced stage of prophase than the hypobasal cell. There is also evidence of centrosomes or centrosome-like structures connected with the nucleus. FIG. 4 represents the second division completed. Later stages (compare FIGS.

3, 4, 5, 6 and 11) indicate that from the hypobasal cell is developed the foot and from the epibasal cell the stalk and sporangium of the mature sporophyte.

A third division follows in either the middle or apical cell of the tier of three (FIG. 4) which results from the first and second divisions. Compare FIG. 5, which shows a tier or series of four cells, with FIG. 4. Then follows (FIG. 6) a division in the basal or foot cell at right angles to the first three division walls. The foot at this stage has become quite dense in protoplasmic contents.

The order of divisions just described seems to represent the usual conditions. Compare, however, FIGS. 2–6 with FIGS. 7–10. In each section represented by FIGS. 7 and 9 there is a triangular-shaped apical cell, while in FIGS. 8 and 10 both apical and basal cells of triangular shape are present. FIG. 11 represents a slightly different condition, in which the foot has become divided into an irregular group of cells.

In no case do we find the same sequence of early divisions as described by Cavers (2). In speaking of the early divisions of the sporophyte of *Reboulia*, he says, "The transverse basal wall is followed by two sets of nearly equal vertical walls which intersect each other at right angles, so that the embryo shows a regular octant stage."

SUMMARY.

The egg and sperm nuclei are both in a resting condition in the earliest stages of fusion.

Among the Bryophytes little is known concerning the details of nuclear behavior during the stages of fertilization.

The earliest divisions of the zygote are transverse. A longitudinal series or tier of four cells may be formed.

Occasionally, however, both apical and foot cells of triangular outline may be formed, or the basal cell may divide into an irregular group which constitutes the foot.

Of the first two cells formed, the hypobasal cell evidently produces the foot, and the epibasal cell the stalk and sporangium of the mature sporophyte.

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EVANSTON, ILLINOIS

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Explanation of plate 19

The figures were drawn by Miss Mary C. Blair.

FIG. 1. Early stage of fusion of the egg and sperm nuclei, × 1775.

FIG. 2. Telophase of first division of zygote, × 565.

FIG. 3. First division of zygote completed; hypobasal cell "a," and epibasal cell "b" in prophase of subsequent division, × 735.

FIG. 4. Division of epibasal cell completed, showing tier of three cells, × 565.

FIG. 5. Young embryo consisting of tier of four cells, × 565.

FIG. 6. Hypobasal cell divided longitudinally; cell next above in process of longitudinal division, × 565.

FIG. 7. Young embryo with wedge-shaped apical cell, × 735.

FIG. 8. Young embryo with both basal and apical cells triangular in shape, × 735.

FIG. 9. Embryo, older than in any of the preceding figures, with wedge-shaped apical cell × 565.

FIG. 10. Slightly more advanced embryo than in FIG. 9, showing both apical and basal cells triangular in outline, × 565.

FIG. 11. Embryo showing early differentiation of foot "a," seta "b," and capsule "c," × 565.

The development of the endosperm in Vaccinium corymbosum

NEIL E. STEVENS

(WITH FOUR TEXT FIGURES)

The occurrence of a "chambered" embryo sac, formed by the development of a transverse wall following the first division of the primary endosperm nucleus, has been reported in four genera of the Ericaceae. In recent studies of the high bush blueberry, *Vaccinium corymbosum* L., the writer has noted a variation from this of sufficient interest to warrant brief publication.

In 1849 Hofmeister (**2**) published an account of the development of *Monotropa Hypopitys*. According to his descriptions and figures (*pl. 12, f. 11*) the embryo sac in this species is first cut in two by a cross wall near the middle; afterwards cross walls are formed in each half and the micropylar end is cut off by a wall, thus resulting in an embryo sac of five superimposed cells. Nine years after the publication cited above Hofmeister described the development of *Vaccinium Myrtillus* and *Pyrola rotundifolia* (**3**), in both of which he found that the development of the endosperm took place as in the *Monotropa* without free nuclear division.

Koch (**4**), in his studies of *Monotropa Hypopitys*, largely confirms the work of Hofmeister. His figure (*pl. 10, f. 12*) closely resembles that of Hofmeister except that he finds no cross wall near the micropylar end and thus figures a four-chambered, instead of a five-chambered, embryo sac.

In the trailing arbutus, *Epigaea repens*, the writer (**5**) found a condition much like that reported in other genera. His figure of the *Epigaea* (*f. 3*) very closely resembles Koch's figure of the *Monotropa*, a fact which the writer apparently overlooked in his earlier paper (**5**, p. 540). The writer also reported the occurrence in the *Epigaea* of haustoria extending out into the tissues of the integument from the ends of the developing endosperm.

The slides of *Vaccinium corymbosum*, on which the present notes are based, were all made from material collected at East

Wareham, Massachusetts, during June, 1916. The material was fixed in a solution of equal parts glacial acetic acid and absolute alcohol, imbedded in paraffin, cut and stained in the usual way. From a study of this material it is apparent that the development of the endosperm of this species may begin in two quite different ways, either by the formation of a cross wall following the first division of the primary endosperm nucleus as has been reported in the other genera of the Ericaceae, or by a period of free nuclear division as has been described in a very large number of species.

FIG. 1 shows a typical two-chambered embryo sac much like those described in *Monotropa* and *Epigaea*. The material examined also showed the four-chambered stage which characteristically follows this. FIG. 2, on the other hand, illustrates an embryo sac which has developed by free nuclear division. The stage represented by FIG. 3 may obviously have resulted from free nuclear division followed by the beginning of wall formation near the center of the embryo sac, or there may have been some free nuclear division after the formation of the cross walls.

FIG. 4 shows a somewhat more advanced stage, in which the irregular arrangement of the cell walls suggests that there was a period of free nuclear division. In this figure the layer of small cells with dense protoplasm (shaded) represents the "tapetum" mentioned in *Epigaea* (5, *f.* 4). The developing haustoria may also be noted. The antipodal haustorium consists of only one cell, while the micropylar haustorium contains three. In the mature seed of *Vaccinium corymbosum* the haustoria are larger than in the seed of *Epigaea repens;* their development also begins relatively early. In *Epigaea* when the embryo is in the eight-celled stage and the endosperm well differentiated both haustoria are still small and consist of but a single cell, whereas in *Vaccinium* the haustoria have attained a considerable size before any divisions of the fertilized egg are apparent.

Hofmeister found that *Vaccinium* (3, p. 141) differed from the other genera described by him in that after the formation of the first wall across the embryo sac, endosperm developed only in the antipodal chamber, while in *Monotropa* and *Pyrola* endosperm developed in both chambers (see also Coulter and Chamberlain, 1, p. 177). The condition found by the writer in *V. corymbosum*

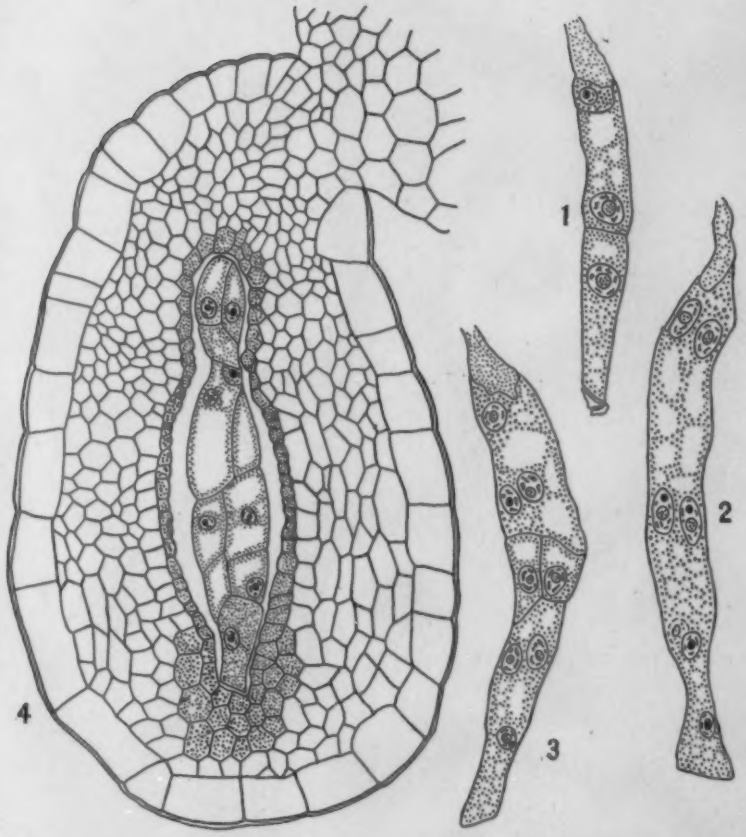

FIG. 1. Longitudinal section of embryo sac of *Vaccinium corymbosum* in two-celled stage; the fertilized egg and the remains of the pollen tube may be seen at the upper end and the remains of the antipodal cells at the lower end. ×290.

FIG. 2. Embryo sac of *V. corymbosum* which shows only free nuclear division. × 290.

FIG. 3. Embryo sac from the same ovary as that in FIG. 2, showing two cross walls and evidence of free nuclear division. × 290.

FIG. 4. Longitudinal section of ovule of *V. corymbosum* showing few-celled endosperm with haustoria developing at either end. The inner cells of the integument are specialized to form a tapetum, being more densely crowded with protoplasm and generally smaller than the other cells of the integument. The walls of the epidermal cells are already somewhat thickened. × 170.

represents a still further variation and suggests the desirability of a careful study of the development of the endosperm in other genera of this family. The writer has, however, been able to examine only one. Slides of *Kalmia latifolia* made from material collected at Vienna, Virginia, on May 28, 1916, showed embryo sacs before division and in the two-celled and four-celled stages. Material collected August 13, 1916, showed the endosperm with haustoria at either end, the whole condition very closely resembling that described in *Epigaea*.

The significance of the condition described in *Vaccinium corymbosum* lies of course in the fact that here occur in a single species types of development hitherto associated with different genera or even different families. All the figures were drawn from material collected from a single plant and FIGS. 2 and 3 represent ovules in the same ovary. Examination of a large amount of material of the other genera described might result in finding variations as marked as those in the *Vaccinium*.

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Three South American species of Asterella*

ALEXANDER W. EVANS

The genus *Asterella* has many representatives on the American continent. Most of the northern species are widely distributed, but the southern and tropical species tend to be more restricted in range. Of the fifteen North American species recognized by the writer in his recent revision† only two are known to extend into South America. These are *A. venosa*, which was based on material from Brazil, and *A. lateralis*, which Spruce collected in Ecuador. No other South American stations for either species have been recorded. In the present paper three species which are not known to extend into North America are discussed. Four other South American species have been described by Stephani in his Species Hepaticarum, but no material of these is available at the present time.

1. **Asterella chilensis** (Mont.) comb. nov.

Fimbriaria chilensis Nees & Mont.; Montagne, Ann. Sci. Nat. Bot. II. 9: 41. 1838.

Hypenantron chilense Trevis. Men. R. Ist. Lomb. III. 4: 441. 1877.

Thallus green, becoming brownish or purplish with age, the ventral scales usually more deeply pigmented, mostly 0.5–1 cm. long and 1.5–2.5 mm. wide, in fertile branches broadening out somewhat at the apex, plane or somewhat concave, the thin and slightly wavy margins not incurved when dry, branching normally by forking, sometimes (according to published descriptions) innovating at the apex, keel broad and rounded; epidermis composed of cells with slightly thickened walls, sometimes with more or less evident trigones, averaging about 35 x 25 μ; pores slightly

* Contribution from the Osborn Botanical Laboratory.

† The North American species of *Asterella*. Contr. U. S. Nat. Herb. 20: 247–312. 1919. In this paper full descriptions may be found of the following species referred to in the present article: *A. elegans* (Spreng.) Trevis., *A. lateralis* M. A. Howe, *A. Lindenbergiana* (Corda) Lindb., *A. Ludwigii* (Schwaegr.) Underw., *A. tenella* (L.) Beauv., and *A. venosa* (Lehm. & Lindenb.) Evans.

elevated, measuring (with their surrounding cells) mostly 90–100 μ in length and 80–90 μ in width, surrounded usually by six (more rarely five or seven to nine) radiating series of cells with two or three cells in each series, radial walls slightly thickened; cells with oil bodies as in *A. tenella;* green tissue loose especially toward the margins, air chambers in two or three layers in the median portion, those of the dorsal layer sparingly subdivided by supplementary partitions and considerably larger than the deeper chambers; compact tissue occupying about two thirds the thickness of the thallus in the median portion, thinning out gradually on the sides and extending about halfway to the margins, composed of thin-walled cells without pits (so far as observed); mycorrhiza present; ventral scales ovate to lunulate, reddish purple throughout or sometimes with bleached appendages, marginal slime-papillae very short-lived, cells containing oil-bodies mostly three to five, scattered, appendages usually borne singly, rarely in pairs, narrowly subulate, scarcely or not at all constricted at the base, mostly 0.3–0.45 mm. long and 0.06–0.12 mm. wide, acuminate, entire (or sometimes, according to Stephani, with a basal spine), the cells mostly 40–60 μ long and 15–35 μ wide: inflorescence paroicous, the antheridia forming a small and vaguely defined group close to the peduncle of the female receptacle: female inflorescence borne on a leading branch, peduncle mostly 1–1.5 cm. high, more or less purple, with small clusters of narrow paleae at base and apex but otherwise naked or nearly so; disc of receptacle green or yellowish, mostly 2–3 mm. across, bluntly conical and usually three- or four-lobed to about the middle, the lobes dilated at the apex, covered over with low coarse tubercles, giving the ends of the lobes a crenate appearance, the involucres broad and undivided, entire or nearly so; pseudoperianths white, extending downward and outward, mostly eight-cleft, the divisions subulate, becoming free with age: capsule wall not studied (hyaline, according to Stephani); spores yellow to brownish yellow, mostly 80–90 μ in diameter, with a thin, wavy, and minutely crenulate wing, 10–16 μ wide along the edges, whole surface covered over with a very fine and irregular reticulum, the meshes mostly 1–5 μ across, formed by a system of delicate anastomosing lines, spherical face showing in addition a coarse reticulum with meshes 16–20 μ across, formed of ridges similar to the wings, plane faces without ridges (so far as observed), margins of wings and ridges more or less broadened; elaters pale yellow, mostly 120–200 μ long and about 6 μ wide, tapering slightly toward the blunt ends, usually with two loosely twisted spirals throughout the entire length.

Known only from Chile; the following specimen has been examined:

CHILE: near Santiago, 1915, *N. Costes* (N. Y.).*

The type material was collected by Bertero near Quillota; Stephani has since reported the species from Pelaquén, *P. Dusén* (in Bih. K. Svensk. Vet.-Akad. Handl. **26** (3[6]): 17. 1900).

According to Montagne's account the capsules of the original material were immature, making it impossible to give any data about the spores and elaters. The description of the gametophyte, however, is unusually full and discusses certain histological features which were usually ignored at that time. It calls attention, among other things, to the thallus broadening out from a narrow linear base; to the elevated pores, making the epidermis appear undulate in cross section; to the large air chambers in the green tissue, arranged in a single layer; to the coarsely tuberculate receptacle, three- or, rarely, four-lobed to the middle, with veiny, truncate lobes; to the apical paleae of the peduncle; to the relatively short pseudoperianth, with six to eight divisions, free at maturity. There is little to criticise in his account, except that the undulate appearance of the epidermis is not always striking and that the air chambers are in more than one layer in the median portion of the thallus. As a matter of fact they are in one layer toward the margin, and the more deeply situated median chambers are difficult to demonstrate in dried material. Stephani, in his description, assigns a paroicous inflorescence to the species, noting the androecium at the base of the peduncle, and adds that the spores are yellow, rough, and broadly winged and that the elaters are hyaline and bispiral. He places the species in the same group as *A. tenella*, *A. macropoda*, and *A. Lindenbergiana*, on account of the shape of the receptacle, which he describes as shortly conical and obtuse at the apex.

In general appearance *A. chilensis* bears a strong resemblance to *A. tenella* and *A. Ludwigii*, and the species agree further in their dichotomous branching; in their paroicous inflorescence; in their normally eight-cleft pseudoperianths, the divisions of which become free at maturity; and in their yellow spores with broad wings along the edges and a coarse surface-reticulum, at least on the spherical faces. Of course the structure of the green tissue

* In the citation of specimens "N. Y." signifies the herbarium of the New York Botanical Garden and "Y," the herbarium of Yale University.

will at once distinguish the Chilean species, the dorsal air chambers being subdivided by supplementary partitions, while those of *A. tenella* and *A. Ludwigii* remain undivided. The basal portions of the ventral scales, moreover, have fewer cells with oil-bodies and the appendages are much more slender. The deeply lobed female receptacle is also a distinctive feature, the lobes being much shorter in *A. tenella* and scarcely evident in *A. Ludwigii*. In *A. venosa*, with which the species was compared by Montagne, the thallus is far more delicate, the disc of the female receptacle is flatter, the spores are smaller, and there is no coarse reticulum on the surface.

2. **Asterella macropoda** (Spruce) comb. nov.

Fimbriaria macropoda Spruce, Trans. Bot. Soc. Edinburgh **15**: 564. 1885.

Fimbriaria canalensis Spruce, *l.c.* 564. 1885.

Fimbriaria Mandoni Steph. Bull. Herb. Boissier **7**: 207. 1899.

Thallus green above and sometimes throughout but usually with the margin and ventral surface more or less pigmented with purple, mostly 2–3 cm. long and 5–8 mm. wide, plane or nearly so with undulate and often crispate margins, branching by forking and also by apical innovations and intercalary ventral outgrowths, keel narrow but rounded: epidermis composed of cells of somewhat thickened walls, sometimes with distinct trigones, averaging about 28 x 24 μ (exceptional cells sometimes 60 μ long); pores somewhat elevated, measuring (with their surrounding cells) mostly 120–140 μ in length and 100–120 μ in width, surrounded by eight (sometimes seven, nine or, rarely, ten) radiating series of cells with four (sometimes three or five) cells in each series, radial walls distinctly thickened, becoming thinner toward the opening; cells containing oil-bodies as as in *A. tenella;* green tissue loose, the air-chambers in three or four layers (in the median portion), those of the dorsal layer sparingly subdivided by supplementary partitions and thus appearing about as large as the deeper chambers; compact tissue occupying about half the thickness of the thallus in the median portion, thinning out gradually on the sides but extending scarcely more than one-tenth the distance to the margin, composed of cells with slightly thickened, pitted walls: mycorrhiza sometimes present; ventral scales ovate and long-decurrent, purple throughout or with the appendages and margins more or less bleached, cells containing oil-bodies mostly eight to twelve, scattered,

slime-papillae short-lived and inconspicuous, marginal cells smaller and more irregular than the median cells, appendages one or two, usually distinctly constricted at the base, narrowly ovate to lanceolate, mostly 0.35–0.75 mm. long and 0.15–0.35 mm. wide, the apex rarely rounded, usually obtuse, acute or apiculate, the margin entire or vaguely crenulate from projecting cells, cells averaging about 45 x 25 μ, one or two smaller cells with oil-bodies often present: inflorescence autoicous: male inflorescence borne on a very short ventral branch (so far as observed), consisting of a cluster of antheridia, variable in number, and destitute of marginal paleae, ostioles short: female inflorescence variable in position, sometimes borne on a branch of a dichotomy, sometimes on a ventral branch, variable in length; peduncle mostly 1.5–5 cm. long, with very long scattered paleae and an apical cluster, more or less pigmented with purple; disc of receptacle often purple, mostly 4–7 mm. across, delicate in texture, the center depressed-hemispherical, mostly four-lobed to about the middle, the lobes spreading almost horizontally, broadening out and separated by sharp sinuses, upper surface covered over with coarse tubercles, making the margins appear crenate, involucres green to purple, undivided, entire or nearly so, not reaching the margins of the lobes; pseudoperianth extending downward and outward, yellowish brown at the base and rarely throughout, usually for the most part deep vinous purple, mostly twelve- to sixteen-cleft, the divisions becoming filiform upon drying, coherent at the apex: capsule brown to purple, circumscissile by an irregular line; spores brown, translucent, mostly 80–90 μ in diameter, with thin and wavy, minutely crenulate wings 12–14 μ wide along the edges, entire surface minutely and closely punctulate or with short and irregular lines, spherical face showing in addition a coarse and usually regular reticulum, the meshes mostly 20–30 μ across, enclosed by the marginal wings and a series of similar anastomosing ridges, each plane face with a similar but often incomplete reticulum, margins of wings and ridges darker and somewhat thicker, marked by subparallel lines, and often showing minute interstices especially at points of junction; elaters brown, variously curved, mostly 300–360 μ long and 8–10 μ wide, tapering slightly to the blunt ends, mostly bispiral throughout.

On rocks and banks of streams; known only from the Andes. The following specimens have been examined:

ECUADOR: Quito, *W. Jameson* (N. Y., listed by Mitten, as *Fimbriaria elegans*, in Jour. Bot. & Kew Misc. 3: 361. 1851); Pichincha, *R. Spruce* (N. Y.; type of *Fimbriaria macropoda*,

distributed in Hep. Spruceanae); Canelos, *R. Spruce* (N.Y., Y.; type of *F. canelensis*, distributed in Hep. Spruceanae).

Stephani lists *Fimbriaria Mandoni* from the following locality:

BOLIVIA: Sorata, *G. Mandon.*

In proposing *Fimbriaria macropoda* as a new species Spruce cited no specimens except those which he himself had collected "in rivuli ripis montis Pichincha." In Stephani's monograph the species is still restricted to the "Andes quitenses," but Jameson, Lindig and Wallis are mentioned as collectors, in addition to Spruce. Stephani states, in fact, that he had not seen Spruce's original material at all. Unfortunately he gives no further information about the specimens which he cites, but it is possible to draw certain inferences from the fact that he does not allude to Jameson, Lindig or Wallis elsewhere in connection with the genus. There is a probability, for example, that Jameson's specimens are those from Quito, listed by Mitten under the name *F. elegans*. There is a further probability that Lindig's specimens are those which Gottsche* referred to *F. Lindenbergiana* on account of their violet-colored capsules. They were collected at Boqueron and Tocarema, in the province of Bogotá, Colombia; and, although these stations are not actually in the "Andes quitenses," they are assuredly in the same general mountainous district. There is also a possibility that Wallis's specimens may have come from Colombia, where most of his South American Hepaticae were collected. Unfortunately the writer has been unable to consult the specimens in question, so that it is impossible to support these inferences by direct evidence.

In Spruce's original description many of the distinctive features of the species are clearly brought out. The delicacy and translucency of the thallus, for example, are emphasized and attention is called to the purple pigmentation of the margin and ventral surface; to the small number of epidermal pores present; to the narrow midrib; to the very long peduncle of the female receptacle, with scattered paleae and a denser cluster at the apex; to the deeply four-lobed disc, covered over with tubercles; to the membranous involucre, narrower than the lobes; to the rose-purple segments of the pseudoperianth, connate at the apex; and

* Ann. Sci. Nat. Bot. V. 1: 187. 1864.

to the large spores with the outer wall pellucid and "laxe celluloso" (in apparent allusion to the coarse surface-network). Spruce ascribed a dioicous inflorescence to the species, probably because the male branches escaped his notice, and stated further that ventral branches were lacking, that apical dichotomies were very rare, that the female inflorescence was terminal (presumably on the main thallus or on one of its innovations), and that the pseudo-perianth was definitely twelve-cleft.

Stephani, in his description, states that the sexual branches are ventral in position and at least implies that forking is less uncommon than Spruce indicates. He definitely assigns an autoicous inflorescence to the species and emphasizes the minuteness of the male branches. He also describes certain structural features omitted by Spruce, such as the green tissue with narrow air chambers and the elevated epidermal pores, each surrounded by six radiating series of cells with four cells in a series. In this last characterization no allowance is made for variability, and the same criticism would apply to his account of the appendages of the ventral scales. According to his statements these are borne in pairs and are approximate, elongated, parallel, lanceolate, and composed of very irregular cells. In the writer's experience the appendages are often borne singly—the only condition mentioned by Spruce—and, although the parallel position of paired scales is sometimes striking, it is by no means constant. Stephani's description of the spores as 63 μ in diameter, yellowish, and broadly "lobate cristate" might also be amplified to advantage.

Spruce's *F. canalensis* was based on material which grew on wet and shaded rocks. As emphasized in the original description the plants are extremely delicate, and the thallus shows almost no signs of pigmentation except on the appendages of the ventral scales. Stephani throws doubt upon the constancy of these features, suggesting that plants of less sheltered situations might perhaps be more robust, and the writer feels that these doubts are amply justified. It may be further shown that the points of resemblance brought out in the descriptions of *F. canalensis* and *F. macropoda* are many and important, while the differences are either insignificant or inconstant, this being true not only of those drawn from the texture and color but also of those drawn from

other structural features. The writer therefore feels compelled to regard the two species as synonyms and maintains the specific name *macropoda* because *F. macropoda* precedes *F. canalensis* in Spruce's work. A careful study of the specimens listed above (which include the types of both species) has also shown that this reduction to synonymy is warranted.

Among the resemblances mentioned by Spruce the following may be cited as important: the narrow midrib; the terminal female receptacle; the slender paleae of the peduncle, clustered at the apex but scattered elsewhere; the tuberculate disc, four-lobed to the middle; and the violet-colored divisions of the pseudoperianth. Stephani adds that the inflorescence in both is autoicous, that the minute male inflorescences are borne on short ventral branches, and that the elaters are bispiral. Among the differences brought out by Spruce it will be sufficient to note the following: in *A. canalensis* the thallus is elongated, the appendages of the ventral scales are lanceolate-subulate, the peduncle is short and the pseudoperianth is sixteen- (or seventeen-) cleft; while in *A. macropoda* the thallus is ovate-oblong, the appendages of the ventral scales are obliquely triangular and acuminate, the peduncle is long, and the pseudoperianth is twelve-cleft. Stephani describes or implies certain further differences in the epidermal pores, in the ventral scales, in the discs of the female receptacles, and in the spores; but a careful scrutiny of his statements, as well as those quoted from Spruce will at once make it evident that these differences would easily come within the range of variability to be expected in the organs concerned.

The writer regrets that no specimens of *F. Mandoni* have been available for study and that the reduction of this species to synonymy might therefore be considered unjustifiable. A careful comparison of Stephani's descriptions, however, will show that the characters separating it from *F. macropoda* are exceedingly questionable, and that most of the organs are described in essentially equivalent phrases. Perhaps the most important differences indicated are those drawn from the ventral scales and the spores. In *F. Mandoni* the appendages of the scales are said to be lanceolate, strongly attenuate, and filiform at the apex, and the spores are described as 90 μ in diameter and broadly lobate-

winged; in *F. macropoda* (as already noted) the appendages are said to be merely lanceolate (nothing further being stated about the apices), and the spores are described as 63 μ in diameter and lobate-cristate. It has aleady been shown that the spores of *F. macropoda* usually (if not always) exceed 63 μ in diameter; and it will at once be obvious that the other differences noted are of very slight significance.

A. macropoda occupies a somewhat unique position in the genus. The structure of the green tissue and the frequent occurrence of a female inflorescence on a long branch derived from a dichotomy indicates a relationship with *A. Lindenbergiana* and *A. venosa*, while the short ventral male branches and the not unusual occurrence of a female inflorescence on a more or less abbreviated ventral branch indicates a relationship with *A. elegans*. Perhaps the relationship to *A. Lindenbergiana* is as close as any, the deep purple pseudoperianths being a very striking feature which both species exhibit. The spores, however, are essentially unlike, those of *A. macropoda* being brown and covered over with a coarse network, while those of *A. Lindenbergiana* are purple and covered over with a much finer and more irregular network. *A. Lindenbergiana* is further distinguished by its more extensive compact tissue and sharper keel, by its smaller and usually narrower scale-appendages, by its frequently paroicous inflorescence, and by the shorter lobes of its female receptacle. From *A. venosa*, with which Spruce compares his species, it differs in the possession of lateral intercalary branches, in its larger epidermal pores and less extensive compact tissue, in its autoicous inflorescence, in its purple pseudoperianths with more divisions, and in its darker, larger and coarsely reticulate spores.

3. **Asterella boliviana** (Steph.) comb. nov.

Fimbriaria boliviana Steph. Spec. Hepat. 6: 11. 1917.

Thallus yellowish green above, usually purple on the ventral surface and along the margin, mostly 1–1.5 cm. long and 4–6 mm. wide, more or less concave, especially when dry, the margins vaguely undulate-crispate, sometimes erect or incurved when dry, branching intercalary and lateral (so far as observed), keel broad and rounded: epidermis composed of cells with distinctly thickened walls, sometimes with indefinite trigones, averaging about 48 x

24 μ; pores elevated, measuring (with their surrounding cells) mostly 100–120 μ long and 70–100 μ wide, surrounded by seven or eight (rarely six or nine) radiating series of cells with three (rarely four or two) cells in each series, radial walls more or less thickened; cells containing oil bodies as in *A. elegans;* green tissue compact, the air chambers narrow, in three or four layers in the median portion of the thallus, those of the dorsal layer abundantly subdivided by vertical supplementary partitions not reaching the epidermis in the vicinity of the pores; compact tissue occupying little more than half the thickness of the thallus in the median portion, thinning out rather abruptly in the sides and extending about halfway to the margin, composed of cells with slightly thickened, pitted walls; mycorrhiza not observed; ventral scales ovate to lunulate, pigmented throughout with a reddish purple or with more or less bleached appendages, cells containing oil-bodies numerous, mostly thirty to sixty, usually scattered but sometimes in pairs or small clusters, tending to be more numerous toward the margin, marginal slime papillae short-lived and inconspicuous, appendages borne singly or in pairs, lanceolate to narrowly ovate merging gradually into the basal portion and scarcely or not at all constricted at the base, mostly 0.7–1.3 mm. long and 0.3–0.35 mm. wide, margin entire or vaguely crenulate or denticulate from projecting cells, acuminate or abruptly apiculate or cuspidate, often tipped with a filament variable in length and variously curved, hooked or contorted, the cells very irregular usually including several with oil-bodies, averaging in the median portion about 70 x 30 μ: inflorescence autoicous: male inflorescence borne on a short and slightly expanded ventral branch, the antheridia forming an irregular median cluster without marginal paleae (so far as observed), ostioles low; female inflorescence borne on a slightly longer and more expanded ventral branch; peduncle more or less pigmented with purple, 1–2 cm. long when well developed, bearing a loose cluster of filiform paleae at the apex and scattered paleae elsewhere; disc of receptacle about 4 mm. wide, bluntly conical, more or less purple, shortly four-lobed, the lobes extending obliquely outward, surface bearing very low and coarse tubercles, especially on the lobes, giving the latter a crenate appearance, involucre not examined; pseudoperianth more or less splotched with purple, mostly eight- to ten-cleft, the divisions subulate, loosely connate at the apex and apparently becoming free at maturity: capsule wall not examined; spores brown or yellowish brown, mostly 90–110 μ in diameter, with wavy, minutely crenulate wings 12–14 μ wide along the edges, spherical face covered over with a coarse and fairly regular network, the meshes mostly 16–20 μ across, formed by a series of anastomosing ridges

similar to the marginal wings, plane faces with similar but more irregular networks, surface otherwise irregularly punctate and marked with fine and irregular lines, especially along the broadened out and darker margins of the wings and ridges, sometimes tending to form secondary and finer networks within the meshes of the coarse network; elaters brown or reddish brown, somewhat curved or often nearly straight, mostly 180–240 μ long and 12–16 μ wide, tapering toward the rounded ends, usually with two or three spirals in the median portion and one or two at the ends.

Known only from Bolivia; the following specimens have been examined:

BOLIVIA: without definite localities or dates, *M. Bang* (N. Y.; two specimens, one numbered *1869*, the other not numbered).

The type locality is described by Stephani as follows: "Hab. Bolivia. (Bong. legit)." In all probability "Bong." is a misprint for "Bang," and the specimens listed above represent a portion of the original material, but this cannot be proved at the present time.

The original description of this distinct and interesting species is far from complete and makes no mention whatever of the epidermis, the green tissue, the spores or the elaters. The author emphasizes the robust and rigid thallus, the ventral and short sexual branches, and the large disc (6 mm. in diameter, according to his statements), semiglobose at the vertex and slightly constricted. He notes further the presence of four campanulate involucres, with large truncate mouths, without saying anything about the lobes of the receptacle, and he describes the ventral scales as large and purple, bearing a large, broadly oval appendage with a long hooked bristle at the apex. The material examined by the writer shows that the ventral scales are more variable than this description indicates and that the hooked apical bristle, although sometimes distinct, is usually represented by a straight or variously contorted or curved bristle. It shows, moreover, the frequent presence of two appendages. Unfortunately the specimens are insufficient to establish an autoicous inflorescence beyond a doubt, only one male branch having been observed; the features of the involucre have likewise been left undetermined in order to avoid the sacrifice of one of the few receptacles, but there is no reason for supposing that the involucre is in any way distinctive.

In the structure of the thallus, in the restriction of the sexual organs to ventral branches, and in many of the characters derived from the female receptacles and the spores, *A. boliviana* shows a close relationship to *A. elegans* and especially to *A. lateralis*. It differs from both of these species in the broader and usually longer appendages of the ventral scales, which are usually much more abruptly contracted into an apical cilium and which are further distinguished by shorter cells and by the frequent occurrence of cells with oil-bodies. In the basal portions of the scales the cells with oil-bodies are unusually abundant, numbering at least twice as many as in *A. elegans* and often five to ten times as many. The elaters of *A. boliviana*, moreover, usually show two spirals at the ends, while those of *A. elegans* and *A. lateralis* usually show only one.

In distinguishing *A. boliviana* from *A. elegans* further characters of importance may be drawn from the sexual branches, the androecia, and the female receptacles. In *A. boliviana* the sexual branches (so far as known) are invariably short; the antheridia form a vaguely defined group without marginal paleae; and the female receptacle is covered over with very short tubercles, scarcely apparent in the central portion: in *A. elegans* the sexual branches vary greatly in length; the antheridia are in a clearly defined and elevated group, surrounded by marginal paleae; and the female receptacle is hemispherical in the center and covered over with longer and more conspicuous tubercles. Some of the characters which separate *A. boliviana* from *A. elegans* are shared by *A. lateralis*, but aside from the important differences derived from the ventral scales and elaters certain other differences derived from the spore markings deserve mention. In *A. lateralis*, except for the coarse reticulum, the spore surface is covered over with crowded and minute dots but not with lines; in *A. boliviana* the surface shows both dots and lines, the latter sometimes anastomosing and thus forming secondary reticula within the meshes of the coarse reticulum.

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INDEX TO AMERICAN BOTANICAL LITERATURE

1914-1919

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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